BOTANICAL GAZETTE

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Apparatus for physiological botany.

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WITH PLATES IX–XII.

I propose to describe in detail some apparatus for physiological botany which I have found very useful in my laboratory. The description may at least serve as a useful suggestion here and there for those wishing to equip a physiological laboratory, but with scanty funds for the purpose.

The apparatus here described is made almost entirely of white pine and with ordinary wood working tools, including a lathe and scroll saw.

The table to which the apparatus is attached when in use consists of a single board one and one-half inches thick, seventeen inches wide and sixteen feet long, fastened by means of iron brackets on a level with the bases of two south windows, and twenty-eight inches from the floor. The table is set out on the brackets two and one-half inches from the wall. See plate X, figure 1.

CENTRIFUGAL MACHINE. Plate IX, fig. 5.—This consists of a wheel *a*, seventeen inches in diameter, which serves as a base for the pan containing the seedlings, and as a pulley for slow motion in other experiments; a small pulley *b*, two and one-half inches in diameter, to carry the belt from the motor when rapid motion is desired; an upright shaft *c*, one and one-half inches in diameter and fourteen and three-fourths inches in length exclusive of the steel cores; and a frame *d*, for mounting the pulleys and shaft as shown in the figures. Steel cores three-eighths inch in diameter are sunk into the two ends of the shaft. The upper core has its exposed end countersunk to admit the point of a large screw that has been tapered with a file while held in the lathe chuck. The core in the lower end of the shaft has been tapered in the same manner as the screw, and fits into an iron piece, seven-eighths inch square and three-eighths inch thick, that has first been slightly hollowed with a five-eighths inch drill to form an oil cup, and then countersunk to receive the point of the core.

The construction of the frame which holds the shaft and pulley is made sufficiently clear by the figures of plate IX and by details *a*, *b*, *c* and *d* of plate X. The steps in the construction of the shaft and pulleys, however, need to be given. A pine stick 2×2 inches is sawed the proper length for the shaft; the centers of the ends are determined by crossing diagonals from the four corners; holes are bored in the center, and the steel cores are driven in, the upper flush with the surface and the lower protruding five-eighths of an inch. The stick is then fastened in the lathe by grasping the end of the lower core in the lathe chuck and bringing the dead center of the lathe into the depression countersunk in the upper core. The ultimate diameter of the shaft is to be one and one-half inches. The stick is now turned to a diameter slightly larger than this; a block is cut two and three-fourths inches square from two inch stuff; a hole one and one-half inches in diameter is bored through its center, and then the shaft is carefully trimmed with the turning gouge, or brought down with coarse sand paper until the block can be crowded on firmly. Then the block, in position flush with the end of the shaft, is turned to two and one-half inches in diameter. Then beginning three-fourths of an inch from what is to be its lower face the block is tapered down to the diameter of the shaft as shown in plate IX, figure 5, *b*. The upper face is made slightly concave, and a V-shaped groove is turned on the edge for the belt.

The pulley is now to be taken off, and after applying glue evenly over the space to be occupied on the shaft it is crowded into its position again. It is advised that the pulley be turned in position before gluing as above described because of the possibility of the block chipping too deeply while roughing off.

To make the large pulley, two pieces slightly over seventeen inches square are cut from one-half inch boards and screwed together with the grains crossing to prevent warping; the two surfaces are dressed true; the center is determined by crossing the diagonals; a circle is marked out from the center seventeen inches in diameter, and a one and one-half inch hole is bored through the center to fit the shaft.

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The circle is now sawed out as accurately as possible on the scroll saw, and then trimmed if necessary with a spoke shave. A V-shaped groove for the belt may be cut on a former machine or with a hand beader. The pulley is now slipped on the shaft, crowded firmly against the small pulley and screwed to it. If the work has been carefully done it will be found when the shaft is adjusted in the frame that the apparatus revolves with perfect ease and accuracy.

A circular zinc pan is made of the diameter of the large pulley and six inches deep, with a tubular opening in the center one and one-half inches in diameter to fit over the pulley shaft. This can be seen in section in plate X, figures 2 and 2′, and in position on the clinostat table, to be described further on, in plate IX, figure 2.

To clamp the apparatus to the table it is placed with its base across the table with the ends of the base projecting on either side. A piece of the same size as the base of the frame, namely 3 × 22 inches, is passed under the table and the table is clamped between these two pieces by bolt and thumbscrew at either end as shown in plate X, figure 1.

To use the apparatus as a centrifugal machine for germinating seeds, the zinc pan is placed over the shaft so that it rests on the large pulley. It will be noticed that the shaft and pulleys can be removed for this purpose by simply unscrewing the large screw (*e*) fitting the upper end of the shaft. Fine white pine sawdust is put into the pan to the depth of four inches, and seeds of beans, peas, corn, etc., planted to a depth of two inches, about five inches from the center. The sawdust is thoroughly moistened and pressed firmly over the seeds; mosquito bar is then spread over the saw dust, and over this is placed wire netting with one inch meshes, so cut as to press snugly against the central zinc tube and the outer wall of the pan. This keeps the sawdust from heaping up against the sides of the pan while revolving rapidly, but does not press too hard against the seedlings, for the whole mass of sawdust loosens up to a considerable extent after the pan is set in motion. If any of the seedlings grow to the surface it is an easy matter to cut away the mosquito bar or even to separate the wire of the netting if this should happen to be in the way. A rubber tube connected with a siphon from a jar of water standing on a shelf above the apparatus is so clamped between two sticks screwed together as to allow a slow dripping of water close against the central zinc tube. Here the centrifugal force is slight and the water has opportunity to soak in while slowly moving to the periphery. After a short time the water supply can be so adjusted as to compensate evaporation without sufficient excess to be thrown out around the side of the pan.

Seedlings of peas, beans and corn have been grown in sawdust in this manner for several days, revolving constantly at a rate of 180 revolutions per minute.

HORIZONTAL CLINOSTAT. Plate IX, figure 3, and details *e, f, g, h, i, j, k, l, m*, of plate X.—A wooden shaft, *e*, is turned 30¾ inches long and 1½ inches in diameter, after a steel core has been inserted and then clamped in the lathe chuck in the manner previously described. A pulley, *g*, 2½ inches in diameter, serving also as a shoulder for the larger pulley and table of the clinostat, *h*, is turned on the shaft in the manner previously described so that its upper face stands ¾ of an inch below the upper end of the shaft. The upper face is hollowed slightly. The table of the clinostat is made of the same size and in the same manner as that of the centrifugal machine, except that the central opening, 1½ inches in diameter, extends only ¾ of an inch deep from the lower surface. This is crowded on the shaft against the small pulley and screwed to it. The core in the lower end of the shaft revolves in an iron bearing similar to the one described for the centrifugal machine. The bearing for the upper end of the shaft, shown in figure *i* of plate X, is made in the following manner: a piece is cut from ⅞ inch stuff 3 inches wide and 27 inches long. Two inches from one end a hole is bored of the diameter of the shaft and a block is cut out through the middle of the hole as shown in the figure. When this is replaced with long screws it serves as an adjustable box for the shaft. To set up the clinostat, the last mentioned piece is laid across the table with the box end projecting inwards. Another piece seven-eighths inch by three inches by twenty-two inches is placed beneath the table and the two pieces are then clamped against the table by means of a bolt and thumbscrew, *k*, at each end of the two pieces. This method of clamping apparatus to the table is easy of execution and insures rigidity; it also affords a simple method of tightening belts by loosening the thumbscrew and slipping the apparatus along the table. The iron cup which receives the core

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